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EXPERIMENTS ON AIRFOILS WITH AILERON AND SLOT

By A. Betz

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"Ergebnisse der Aerodynamischen Versuchsanstalt zu Göttingen"

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Report II, No. IV, 8, gives the results of "Tests on Slotted Wings" (For translation see McCook Field Memo Report No. 124). The present report contains the results of a few experiments on three airfoils to which the rear portions, having chords respectively 1/4, 1/3, and 2/5 of the total chord, are hinged so as to form ailerons, especial attention being given to the shape of the slot between the aileron and the main portion of the airfoil. The shape and arrangement of the airfoils, together with the size of the ailerons and slots, are shown in Figure 1. The front portion was the same in all three cases, as likewise the location of the aileron hinge D.

The airfoils, made in the usual manner from sheet metal and plaster of Paris, were rectangular with a span of 120 cm (47.24 in.) and respective chords of 18, 20, and 22 cm (7.09, 7.87, and 8.66 in.). The manner of suspension from the three-component balance was the same as for the "Experiments with Three Horizontal Empennages" (See N.A.C.A. Technical Memorandum

*"Untersuchungen an Flügeln mit Klappen und Spalt." From "Ergebnisse der Aerodynamischen Versuchsanstalt zu Gottingen," Report III, 1927, pp. 107-112.

No. 419, Fig. 2).

The magnitude of the air forces on the different airfoils at different aileron settings was first determined. Complete tests were made for only two aileron settings. In one series of tests, the upper or suction side of the airfoil remained practically constant, and in the other series the lower or pressure side. These settings corresponded to the following aileron deflections β, which are specially noted in the diagrams and tables.

Aileron 1: Suction side constant at $\beta = -3^\circ$,
Pressure side constant at $\beta = -14^\circ$;

Aileron 2: Suction side constant at $\beta = +3^\circ$
Pressure side constant at $\beta = -11^\circ$;

Aileron 3: Suction side constant at $\beta = +2^\circ$
Pressure side constant at $\beta = -9^\circ$.

The zero position of the ailerons is shown in Figure 1, as also the reference line for the angle of attack. Perfect constancy could not be attained on the pressure side since, due to the position of the pivot in the upward deflection of the aileron, its leading edge was lowered, thus altering the outline of the under side of the airfoil at this point. In the other aileron settings tests were made only in the vicinity of the point of maximum lift.

Figures 2-4 and Tables I-XIV contain the results of this first series of experiments. The reference surface, taken as the basis for the calculation of the coefficients, is the maximum projection area of the airfoil at $\beta = 0$. The maximum chord corresponding to this position was taken as the airfoil chord for the calculation of c_m. The reference axis for the moments is the leading edge of the airfoil or its projection on the chord corresponding to the usual definition (Page 32 of Report I). As was to be expected, the lift increased with increasing deflection of the aileron accompanied, however, by an increase in the drag. The flow also became detached at smaller angles of attack for large aileron deflections than for small angles or for no deflection.

The aileron moment was found by another series of experiments, in the same was as for the horizontal empennage, but in each case for only two angles of attack of the whole airfoil. The aileron moment M_k and the moment coefficient c_k were calculated in a way similar to the one used for calculating the elevator moment (See N.A.C.A. Technical Memorandum No. 419). In Figure 5 the c_k values are plotted against the angle of attack α and the aileron deflection β. Contrary to the case of the horizontal empennage with a symmetrical profile, a considerable increase in the aileron moment with increasing size of aileron is sometimes found, while the magnitude of the angle of attack does not make so much difference here.

The numerical values of the moment coefficients are contained in Tables XV-XVII.

Wing with Aileron 1

Span b=120 cm; Total chord t=18.0 cm; Total area F=2160 cm²

TABLE I.

Aileron deflection $\beta = -3^\circ$

Suction side constant

α	100 c_a	100 c_w	100 c_m
-6.4°	-29.7	2.68	1.3
-0.5	+ 8.4	1.55	10.0
+2.4	33.5	2.11	17.5
5.3	55.1	3.14	22.4
11.1	93.7	6.55	31.6
14.1	108.2	8.58	33.8
17.0	125.3	12.5	39.4
20.0	125.5	17.7	40.1

TABLE II.

Aileron deflection $\beta = -14^\circ$

Pressure side constant

α	100 c_a	100 c_w	100 c_m
-6.3°	-41.5	3.22	-4.4
-0.5	- 9.4	1.61	+0.4
+2.5	+11.6	1.50	5.3
5.4	35.4	2.03	11.5
11.2	79.5	4.92	23.8
17.1	110.5	9.95	31.1
20.1	110.2	13.6	30.7

TABLE III.

Aileron deflection $\beta = 17^\circ$

α	100 c_a	100 c_w	100 c_m
13.9°	151.6	17.2	57.5
16.9	156.5	22.2	59.0
19.9	153.2	26.6	57.5

TABLE IV.

Aileron deflection $\beta = 29^\circ$

α	100 c_a	100 c_w	100 c_m
13.8°	170.2	24.4	69.5
16.8	172.0	29.2	69.5
19.9	162.9	33.2	65.1

TABLE V.

Aileron deflection $\beta = 37^\circ$

α	100 c_a	100 c_w	100 c_m
13.8°	182.0	29.9	77.9
16.8	183.0	33.4	76.0
19.8	165.9	39.2	71.0

TABLE VI.

Aileron deflection $\beta = 52^\circ$

α	100 c_a	100 c_w	100 c_m
10.8°	188.0	28.7	86.5
13.8	188.7	33.1	84.2
16.8	184.5	38.8	80.5
19.8	167.2	44.9	75.1

Wing with Aileron 2.

Span b=120 cm; Total chord t=20.0 cm; Total area F=2400 cm².

TABLE VII.

Aileron deflection $\beta = 3^\circ$

Suction side constant

α	100 c_a	100 c_w	100 c_m
-0.7°	53.6	3.25	32.2
+5.1	92.0	6.70	41.2
10.9	129.2	12.6	50.0
16.9	148.5	20.4	54.0
19.9	143.0	24.4	52.4

TABLE VIII.

Aileron deflection $\beta = -11^\circ$

Pressure side constant

α	100 c_a	100 c_w	100 c_m
-6.3°	-49.8	4.30	-10.1
-0.5	- 9.8	1.42	+ 0.2
+2.5	+12.0	1.29	5.6
5.4	33.1	1.81	10.7
11.2	75.5	4.40	21.4
17.0	111.4	10.3	31.9
20.0	111.2	14.3	32.4

TABLE IX.

Aileron deflection $\beta = 45^\circ$

α	100 c_a	100 c_w	100 c_m
10.7°	187.0	35.3	85.7
13.7	188.0	39.8	83.6
16.7	178.4	45.8	81.6

TABLE X.

Aileron deflection $\beta = 61^\circ$

α	100 c_a	100 c_w	100 c_m
10.7°	192.0	41.4	86.4
13.7	192.0	43.2	85.4
16.7	178.0	48.4	81.6

Wing with Aileron 3.

Span b=120 cm; Total chord t=22.2 cm; Total area F=2660 cm².

TABLE XI.

Aileron deflection $\beta = 2^\circ$

α	100 c_a	100 c_w	100 c_m
-0.9	72.7	4.96	40.1
+5.0	108.4	9.60	48.3
10.8	142.1	16.6	55.8
16.7	157.9	25.8	59.6
19.8	145.0	30.2	57.0

TABLE XII.

Aileron deflection $\beta = -9^\circ$

α	100 c_a	100 c_w	100 c_m
-6.2	-59.7	5.16	-15.7
-0.4	-25.3	2.06	- 7.2
-2.5	+ 0.2	1.26	+ 0.2
+5.4	22.7	1.57	6.2
11.2	64.9	3.80	16.9
17.0	103.3	8.96	27.7
20.0	110.3	13.2	31.8

Wing with Aileron 3 (Cont.)

Span $b=120$ cm; Total chord $t=22.2$ cm; Total area $F=2660$ cm²

TABLE XIII.

Aileron deflection $\beta = 46^\circ$

α	100 c_a	100 c_w	100 c_m
10.6°	183.0	37.4	81.0
13.5	184.8	42.6	81.9
16.7	168.9	45.4	75.3

TABLE XIV.

Aileron deflection $\beta = 53^\circ$

α	100 c_a	100 c_w	100 c_m
7.6°	181.8	40.5	85.1
10.6	188.2	43.5	85.5
13.6	186.0	47.2	85.2

TABLE XV.

Wing with Aileron 1.

Aileron Area $F_K = 552$ cm²;

Aileron Chord $t_K = 4.6$ cm

Angle of attack α	Aileron deflection β	100 c_K
3°	-14°	1.84
"	- 3	2.18
"	+29	5.98
18°	-14°	1.83
"	- 3	0.77
"	+17	6.14
"	29	9.53

TABLE XVI.

Wing with Aileron 2.

Aileron Area $F_K = 792$ cm²;

Aileron Chord $t_K = 6.6$ cm

Angle of attack α	Aileron deflection β	100 c_K
3°	-11°	0.76
"	+ 3	6.35
"	57.5	29.00
18°	-11°	2.48
"	+ 3	10.03
"	42.5	24.80

TABLE XVII.

Wing with Aileron 3.

Aileron Area $F_K = 1055$ cm²;

Aileron Chord $t_K = 8.8$ cm.

Angle of attack α	Aileron deflection β	100 c_K
3°	-9°	0.80
"	+2	12.63
"	46	28.25
15°	-9°	4.73
"	+2	15.10
"	46	30.66

Translation by
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National Advisory Committee for Aeronautics.

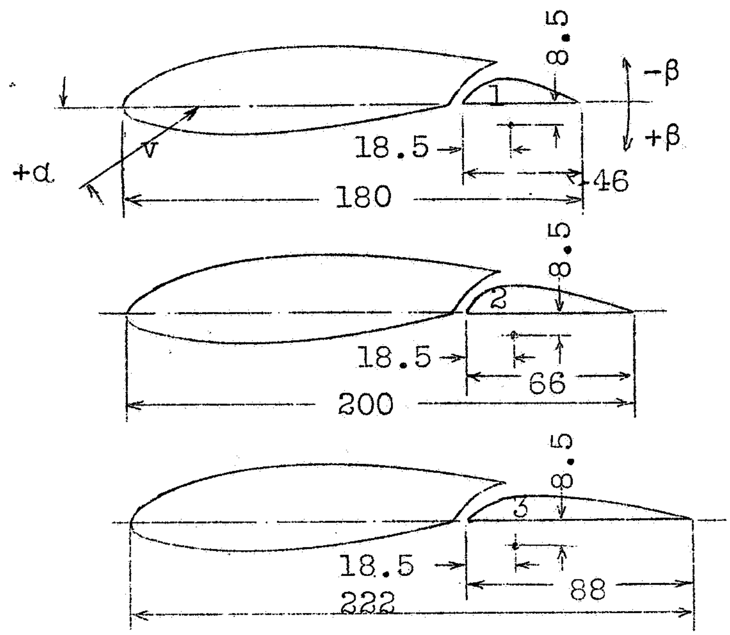
8.5
1
-β
+β
+α
V
18.5
46
180
8.5
2
18.5
66
200
8.5
3
18.5
88
222

Fig.1

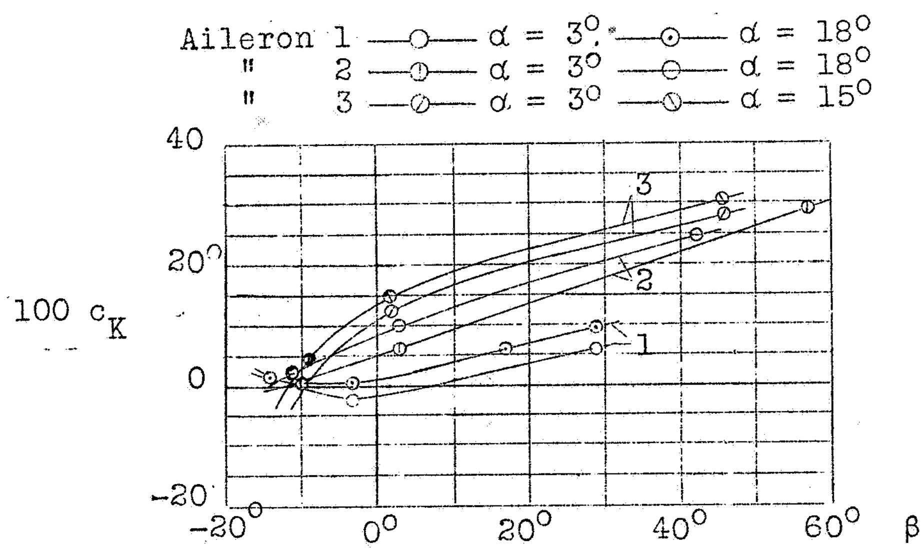
Aileron 1 α = 3° α = 18°
" 2 α = 3° α = 18°
" 3 α = 3° α = 15°
40
20
0
-20
100 c_K
-20°
0°
20°
40°
60°
β
1
2
3

Fig. 5

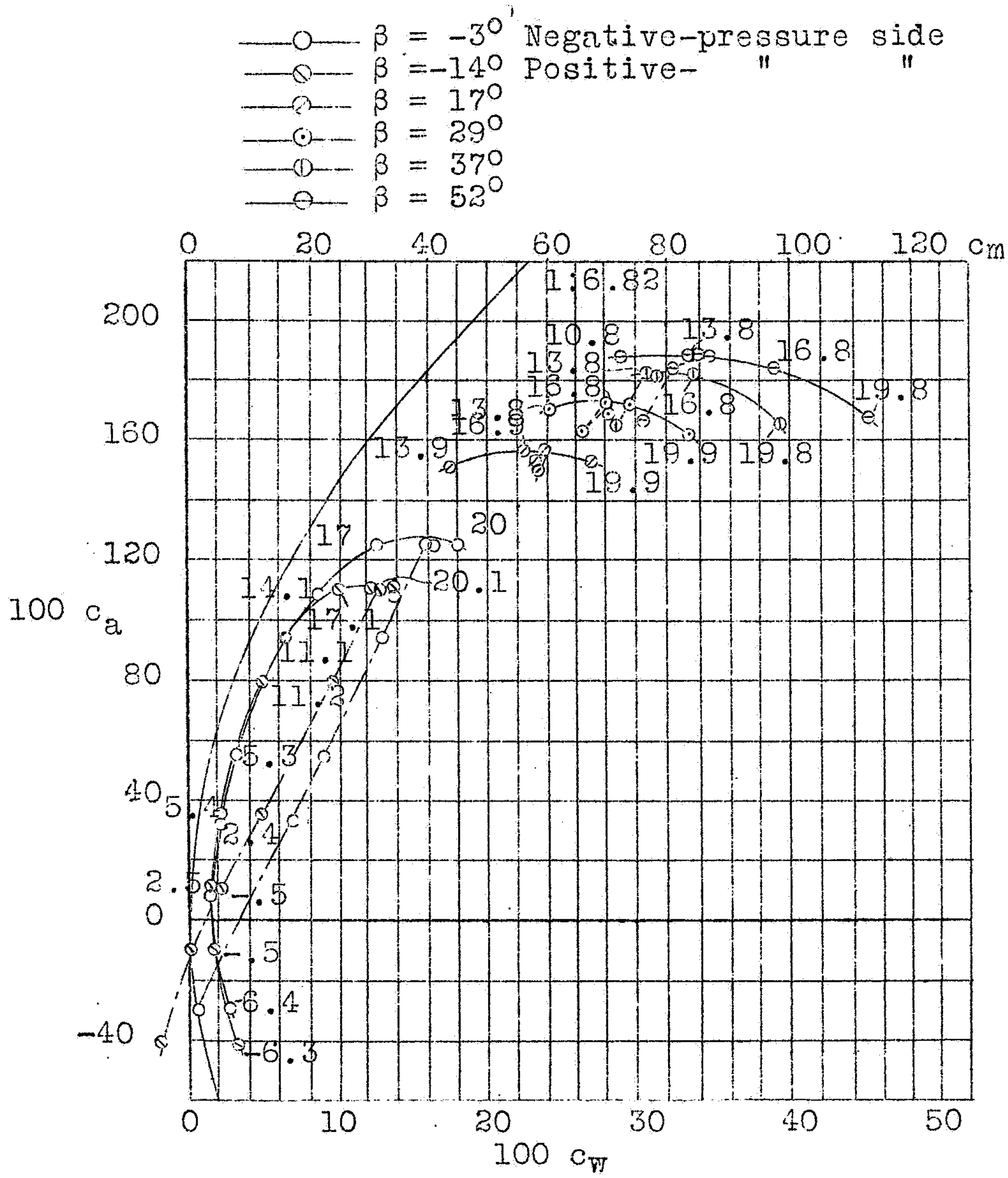
β = -3° Negative-pressure side
β = -14° Positive- " "
β = 17°
β = 29°
β = 37°
β = 52°
100 c_a
100 c_w
c_m
1:6.82

Fig.2

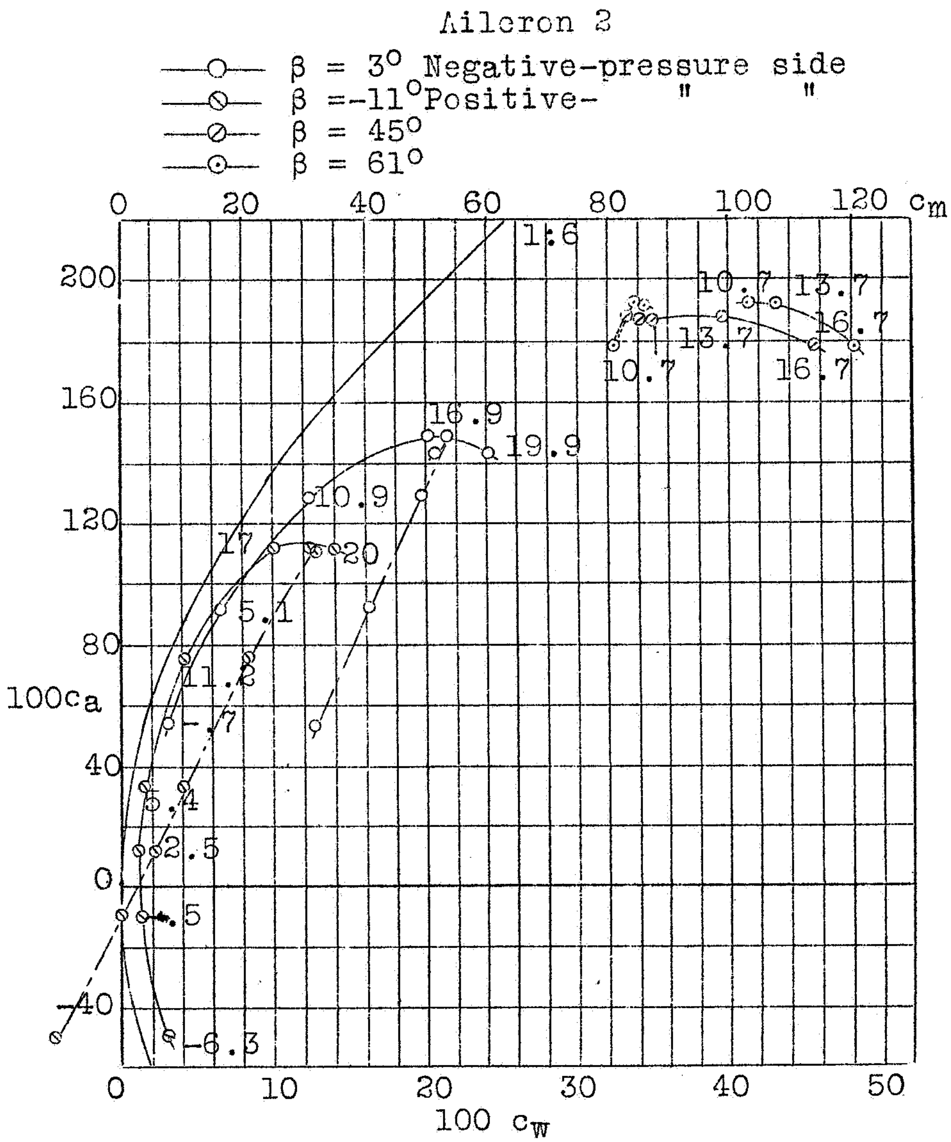
Aileron 2
β = 3° Negative-pressure side
β =-11° Positive- " "
β = 45°
β = 61°
0 20 40 60 80 100 120 cm
1:6
10.7 13.7
16.7
13.7
10.7
16.7
16.9
19.9
10.9
17
20
5.1
11.2
-.7
5.4
2.5
-.5
-6.3
200
160
120
80
40
0
-40
100ca
0 10 20 30 40 50
100 cw

Fig.3

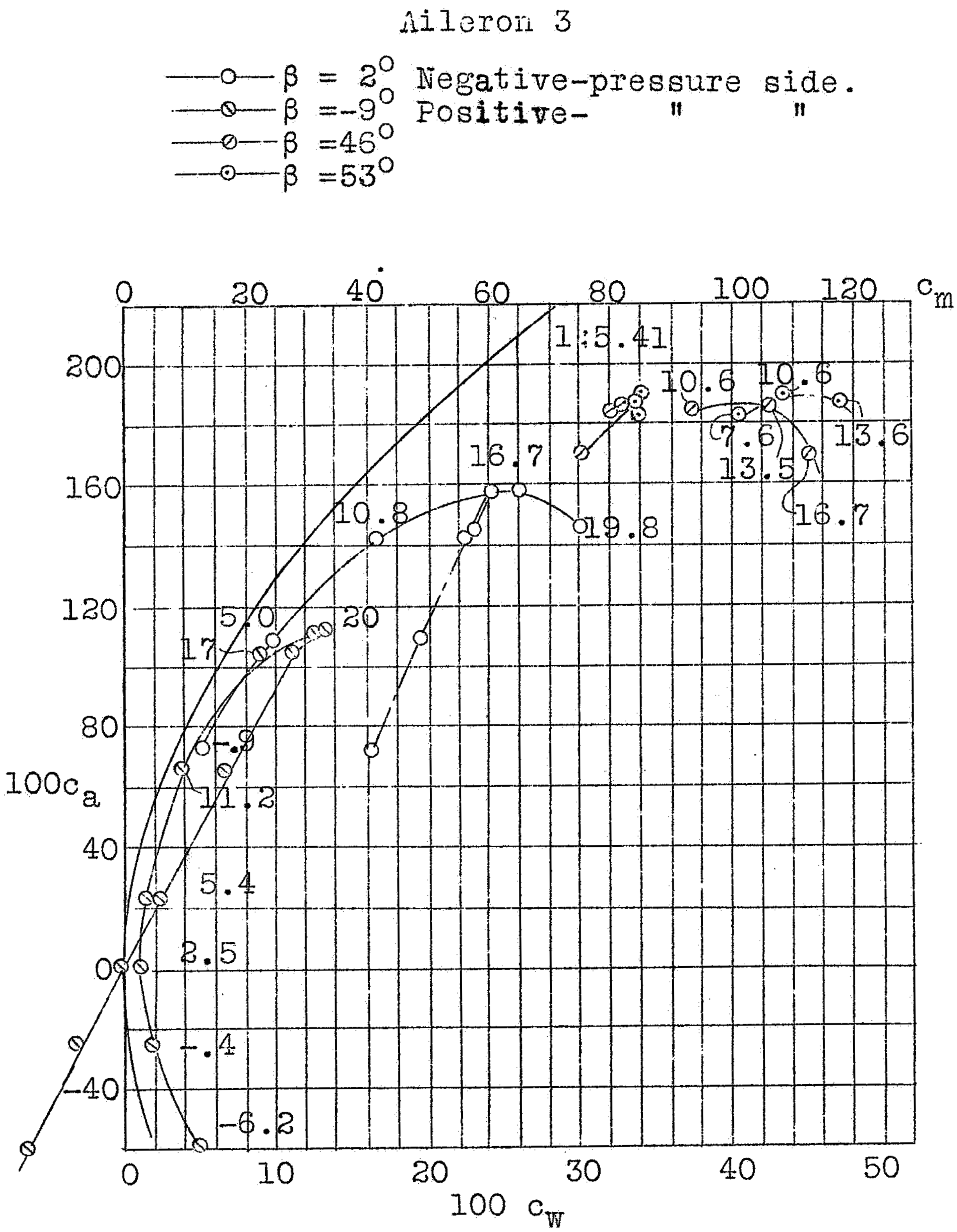
Aileron 3
β = 2° Negative-pressure side.
β =-9° Positive- " "
β =46°
β =53°
0 20 40 60 80 100 120 c_m
1:5.41
10.6
10.6
7.6
13.6
13.5
16.7
16.7
10.8
19.8
5.0
20
17
-.9
11.2
5.4
2.5
-.4
-6.2
200
160
120
80
$100c_a$
40
0
-40
0 10 20 30 40 50
100 c_w

Fig.4